GASOLINE CHARACTERISTICS

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

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GASOLINE CHARACTERISTICS

A THESIS

PRESENTED BY

HARRY G. MOUAT
MAURICE L. WILCOX

TO THE

PRESIDENT AND FACULTY

OF

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Dean of Cult. Studies

TABLE OF CONTENTS.

Page
Table of Contents - - - - - - - - - - - - - - - 2
List of Illustrations and Curve Sheets - - - 3

Part I

The Effect of Temperature on Viscosity - - - 5

Part II

The effect of Pressure on the Boiling Point - 14

Part III

Measurements of Flow -

Taper Pin Flow-Meter - - - - - - - - - - - 22
Indicating Flow-Meter - - - - - - - - - - 28
Proposed Indicating Flow-Meter - - - - - 44

Appendix

Bibliography - - - - - - - - - - - - - - - - - 46

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LIST OF ILLUSTRATIONS AND CURVE SHEETS.

Page

Table I - - - - - - - - - - - - - - 7
Curve Sheet I - - - - - - - - - - - - - - 8
Curve Sheet II - - - - - - - - - - - - - - 9
Curve Sheet III - - - - - - - - - - - - - - 11
Figure I - - - - - - - - - - - - - - 15
Table II - - - - - - - - - - - - - - 19
Curve Sheet IV - - - - - - - - - - - - - - 20
Figure II - - - - - - - - - - - - - - 23
Figure III - - - - - - - - - - - - - - 25
Figure IV - - - - - - - - - - - - - - 29
Table III - - - - - - - - - - - - - - 31
Curve Sheet VII - - - - - - - - - - - - - - 32
Figure V - - - - - - - - - - - - - - 34
Table IV - - - - - - - - - - - - - - 35
Curve Sheet V - - - - - - - - - - - - - - 36
Table V - - - - - - - - - - - - - - 39
Curve Sheet VI - - - - - - - - - - - - - - 40
Table VI - - - - - - - - - - - - - - 42
Curve Sheet VIII - - - - - - - - - - - - - - 43
Figure VI - - - - - - - - - - - - - - 45

PART I.

THE EFFECT OF HEAT ON VISCOSITY.

One of the characteristics of gasoline, as well as other mineral oils, is its change of rate of flow under change of temperature. This is due to the effect of heat on the viscosity of the liquid. In order to obtain data upon this change of viscosity, experiments were carried out, using gasoline and kerosene. Data pertaining to the heavier mineral products was obtained from a pamphlet of the Vacuum Oil Company's Oil Samples.

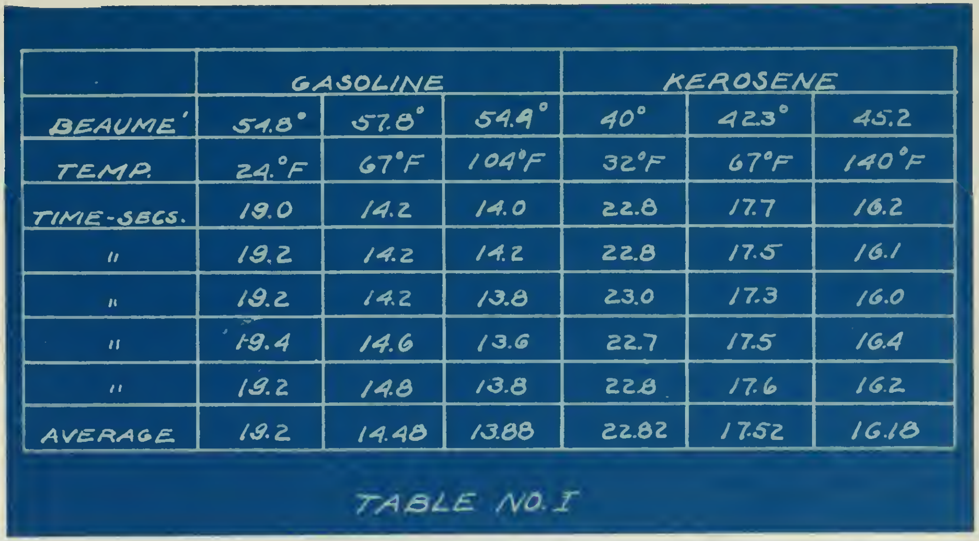
The viscosities were measured in terms of Saybolt which is the time of flow of 50 c.c., through a standard nozzle. In this case the 70 degree nozzle was used. Samples of gasoline and kerosene were allowed to stand in the oil laboratory for some time until their temperature was approximately that of the room. A 50 c.c. sample was then run through the viscosimeter, its flow being timed by a stop watch. Several readings were taken and the average assumed to be correct. The temperature of the liquid and the degrees Beaume were also recorded. The Beaume reading was corrected for temperature.

The viscosimeter and samples were then taken outside on a cold day and allowed to cool to about 24 degrees F.

The above procedure was then repeated. Samples of gasoline and kerosene were then heated by the steam cylinder of the engine in the engine room to a temperature of over 100 degrees F. The viscosity and other readings were then taken as before except that the average temperature was recorded because the fluid cooled somewhat during the operation. The data collected appears in Table No.I.

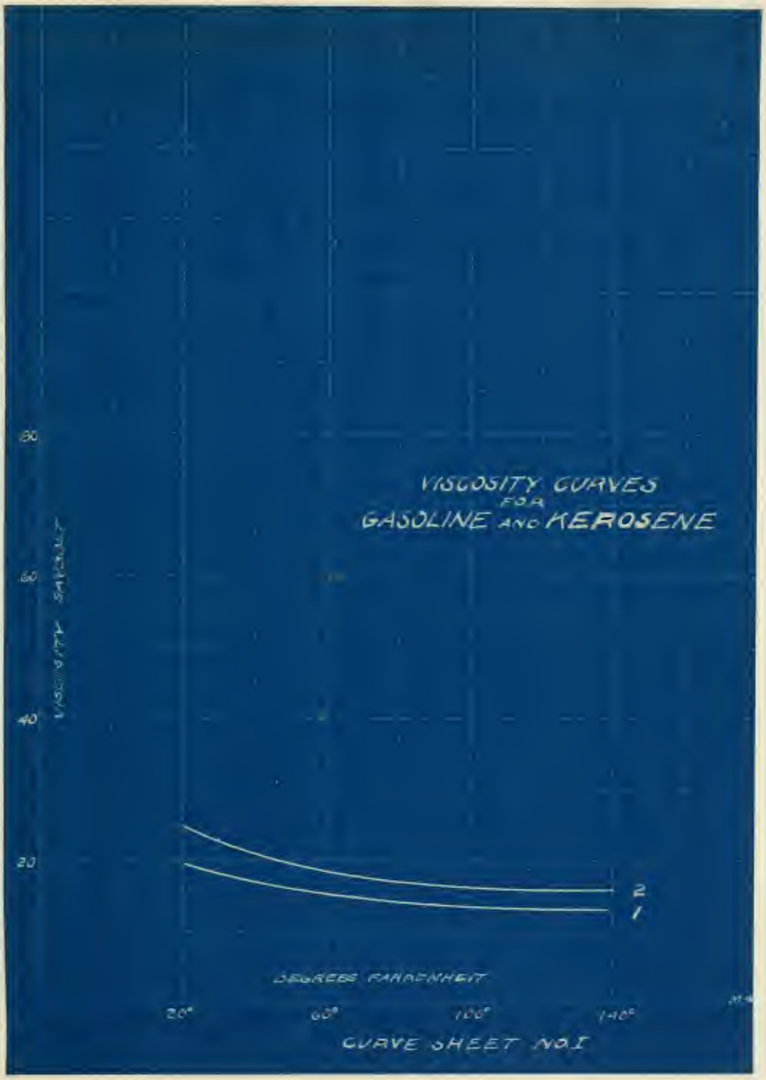
It was found that the viscosity of both the gasoline and the kerosene decreases with the increase of temperature and that the viscosity of the gasoline is slightly lower than that of kerosene. These results are shown plotted as curves I and 2 on Curve Sheet No.I. The curves are nearly parallel, showing that an increase in temperature causes about an equal decrease in the viscosity of both gasoline and kerosene.

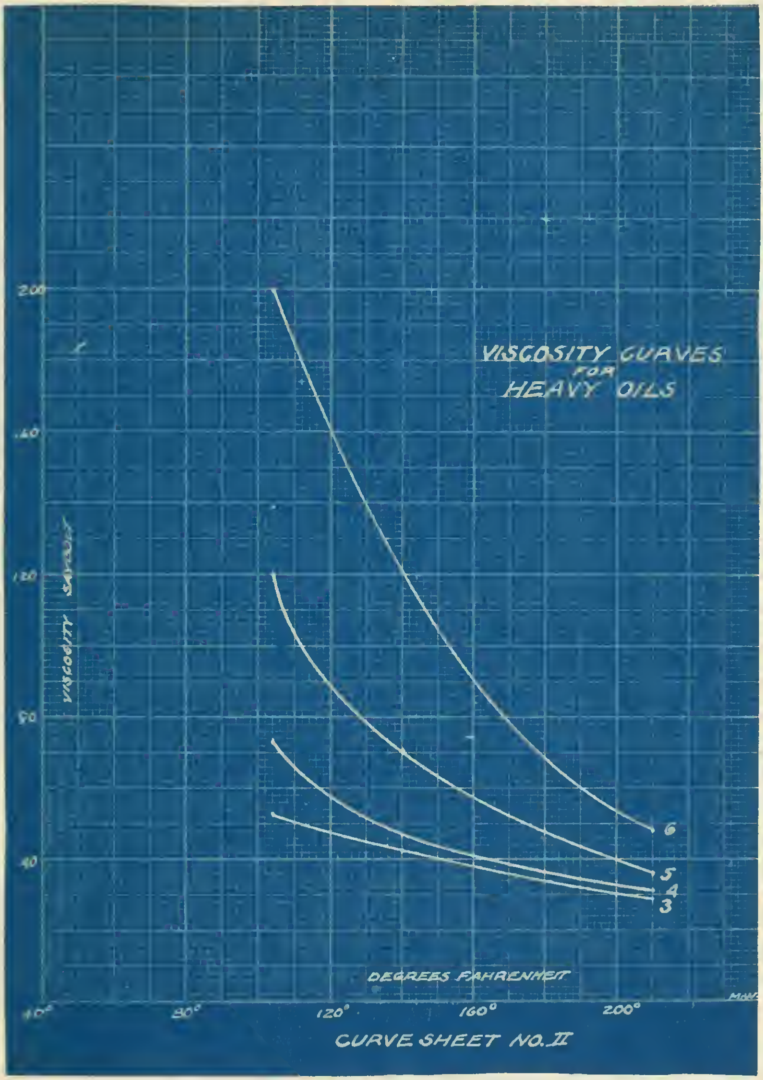
The data obtained from the Vacuum Oil Company is shown plotted in curves 3, 4, 5, and 6 on Curve Sheet No.II. The range of temperatures is somewhat different than was possible to obtain with the lighter oils, but it may easily be seen from the shape of the curves that the change in viscosity, due to a change in temperature, is very much



	GASOLINE			KEROSENE		
BEAUME'	54.8°	57.8°	54.9°	40°	42.3°	45.2
TEMP.	24.°F	67°F	104°F	32°F	67°F	140°F
TIME-SECS.	19.0	14.2	14.0	22.8	17.7	16.2
"	19.2	14.2	14.2	22.8	17.5	16.1
"	19.2	14.2	13.8	23.0	17.3	16.0
"	19.4	14.6	13.6	22.7	17.5	16.4
"	19.2	14.8	13.8	22.8	17.6	16.2
AVERAGE	19.2	14.48	13.88	22.82	17.52	16.18

TABLE NO. I


VISCOSITY CURVES
FOR
GASOLINE AND KEROSENE
80
60
40
20
VISCOSITY SAYBOLT
2
1
DEGREES FAHRENHEIT
20°
60°
100°
140°
CURVE SHEET NO. I

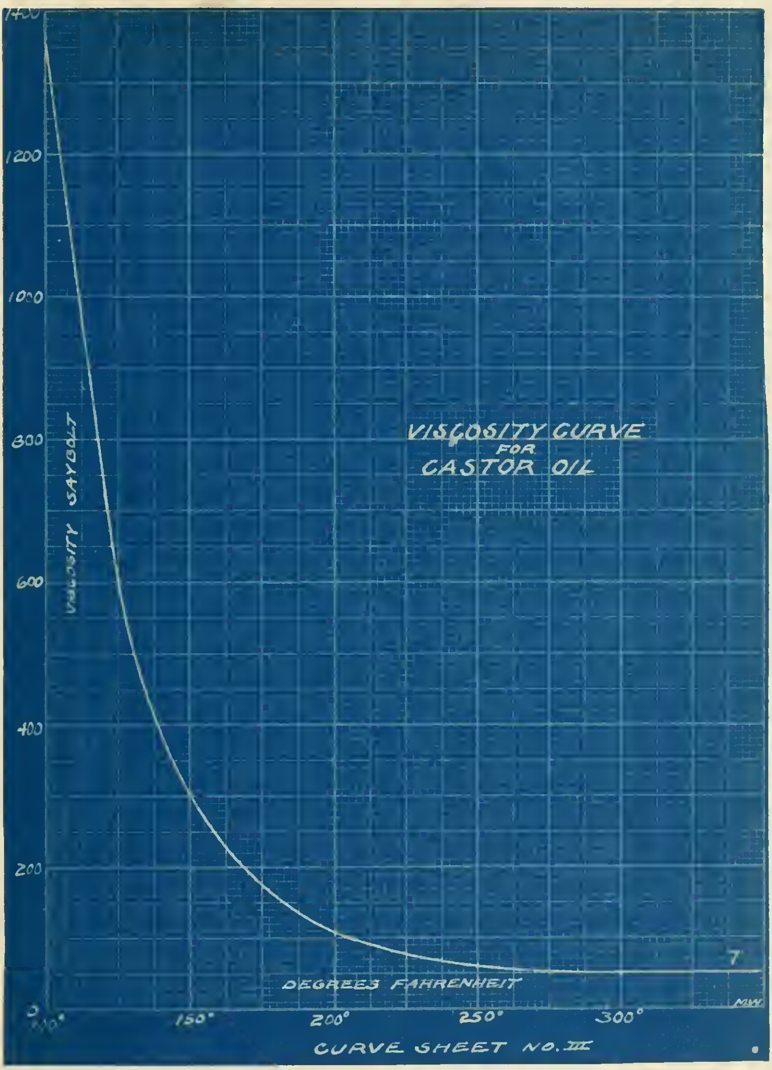


CURVE SHEET NO. II

greater than was observed for the gasoline and kerosene.

Curve No.7 on Curve Sheet No.III was taken from the Transactions of the Society of Automobile Engineers: an article on "Automobile Lubrication" by C. W. Stratford. It shows the effect of heat on the viscosity of chemically pure Castor Oil, a standard product. It may be noticed that the curve becomes nearly asymptotic at high temperatures.

From the results of this experimenting and data obtained from other sources, it may be concluded that a change of temperature has a noticeable effect upon the flow of gasoline and other mineral products. An instrument for measuring the flow of such liquids must therefore be calibrated for such changes if it is to be used under variable temperature conditions.



VISCOSITY CURVE FOR CASTOR OIL

CURVE SHEET NO. III

DATA PERTAINING TO VACUUM OIL COMPANY'S OIL SAMPLES.

1. Gargoyle Velocite Spindle -

A high speed spindle oil for use with wells.

33.6° to 34.5° Beaume
320° flash test
Viscosity: 52-55 at 104 F.
43 at 140 F.
29 at 210 F.

20° cold test
365° fire test
Color, 3/4
Cost, 21 cents

2. Gargoyle Velocite Loom -

32° to 33° Beaume
345° flash test
Viscosity: 72-75 at 104 F.
47 at 140 F.
31 at 210 F.

20° cold test
400° fire test
Color, 7 to 9
Cost, 26 cents

3. Arctic Machine -

A straight mineral oil.

30° to 31° Beaume   20° cold test

385° flest test   440° fire test

Viscosity: 116-122 at 104 F.

65 at 140 F.   Color, 50 to 55

36 at 210 F.   Cost, 32 cents.

4. Cutting Oil "A" -

Compound of 20 per cent rape seed.

26° to 27.2° Beaume   15° cold test

355° flash test   415° fire test

Viscosity: 195-205 at 104 F.   Color, 17

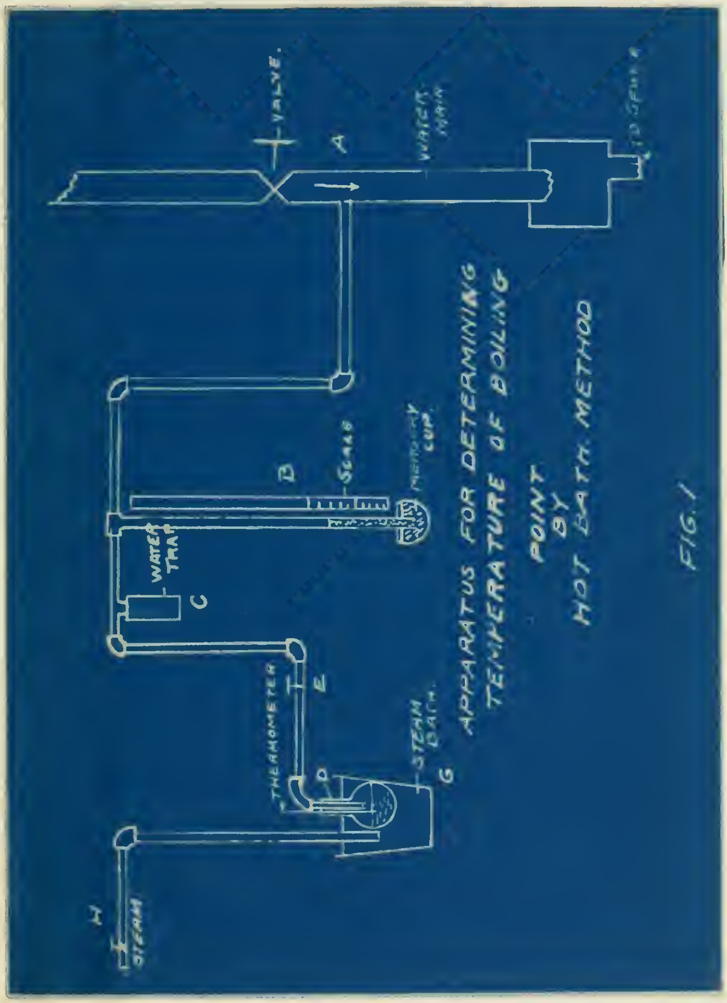
48 at 210 F.   Cost, 50 cents.

PART II

THE EFFECT OF PRESSURE ON THE BOILING POINT.

Another characteristic of gasoline is its change of boiling point under change of pressure. In motor car work, gasoline as it is fed to the carbureters, is not under atmospheric pressure. The suction of the engine or the vacuum feed reduces the pressure on the gasoline and the pressure feed, and other methods increase the pressure. Although the gasoline does not actually boil in ordinary motor car practice, it does something similar - it vaporizes. The ease with which this vaporization takes place determines the ease with which the engine is started and run. The pressure and temperature of the gasoline have a great deal to do with the vaporization. If the pressure of the atmosphere is low, the boiling point of the gasoline will be low and also it will vaporize more rapidly than at a higher pressure.

Measurements of vaporization points under various pressures are hard to obtain, but the various boiling points are easily determined. Apparatus was set up as shown in Figure I. The partial vacuum was created by the aspiration effect of the water passing the opening (A).



APPARATUS FOR DETERMINING TEMPERATURE OF BOILING POINT BY HOT BATH METHOD

FIG. 1

The degree of vacuum was indicated in inches of mercury on the scale (B) and a water trap (C) prevented any water from backing up into the flask (D). Piping and rubber tubing connected the water trap with the flask through the petcock (E). A thermometer was sealed into a rubber stopper and the stopper, in turn, sealed into the flask after a sample of gasoline had been selected. The temperature of the gasoline was controlled by the steam bath (G) which consisted merely of a pail of water into which steam is injected through the valve (H). By partly closing the petcock (E) any degree of vacuum within the range of the apparatus may be obtained. Owing to slight leaks at the various connections, a vacuum of 21 inches was the maximum obtainable.

When the apparatus was first set up, the water trap was not inserted and difficulties were encountered by the water sucking into the mercury tube and flask. The water trap, consisting of a short piece of pipe, closed at the end, solved this difficulty.

With the maximum vacuum obtainable at the surface of the gasoline, steam was slowly admitted to the water until the bubbles started to rise. This was called the boiling

temperature as recorded by the thermometer.

The vacuum was then decreased about two inches and the temperature of the water and gasoline raised until bubbles were given off again. This procedure was carried out till a 8.5 inch vacuum was reached, at which the gasoline could not be made to boil at the temperature obtainable with the steam bath.

A sample of kerosene was heated to the maximum temperature, 191° F. under a vacuum of 19.8 inches of mercury, but it did not show any signs of boiling.

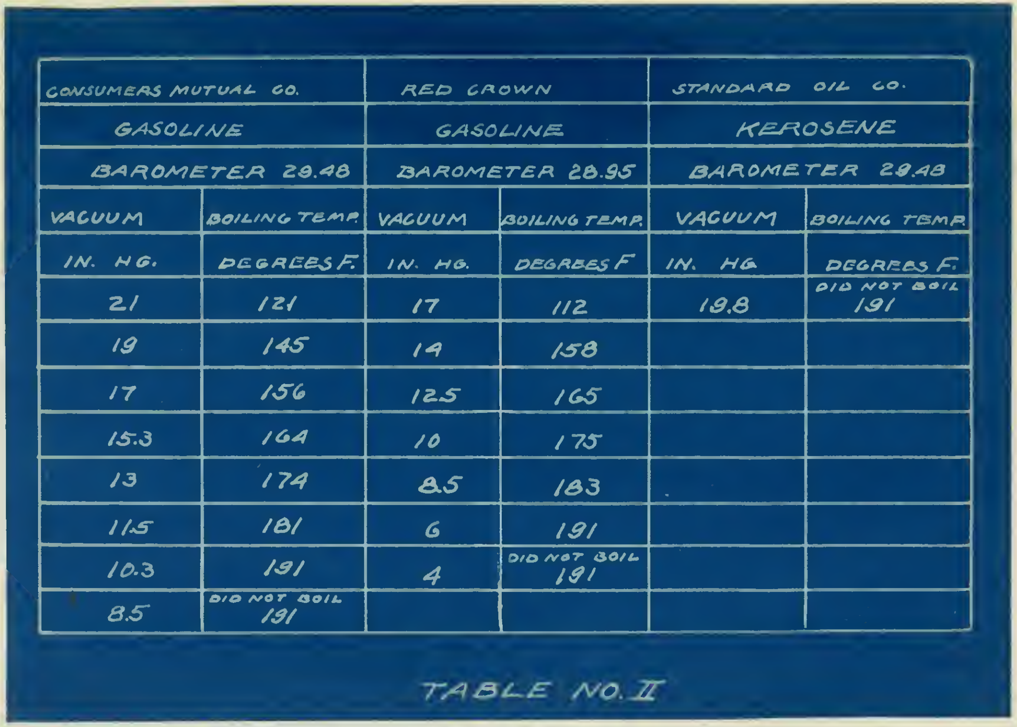
A sample of a different kind of gasoline was then experimented on and found to boil at a somewhat lower temperature than the first sample. This fact indicates that it would also vaporize more easily than the first sample. However, the ease with which boiling or vaporization takes place is not the only determining factor in the value of certain gasoline for motor use.

The refiner grades his gasoline by the initial boiling point, the maximum boiling point and intervening boiling points. He distills a given quantity, and while it is in the process of distillation, ascertains at what point each 10 per cent will boil until the entire quantity is evaporated

or distilled. The low initial boiling point insures ease of starting, the higher boiling points, maximum power, and the intermediate boiling points ever increasing power and force to the explosion. If a gasoline contained only low and high boiling points, there would be an explosion from the low boiling points but the remainder would be expelled in the exhaust. The intermediate boiling points remedy this: they act as a fuse between the low and high boiling points.

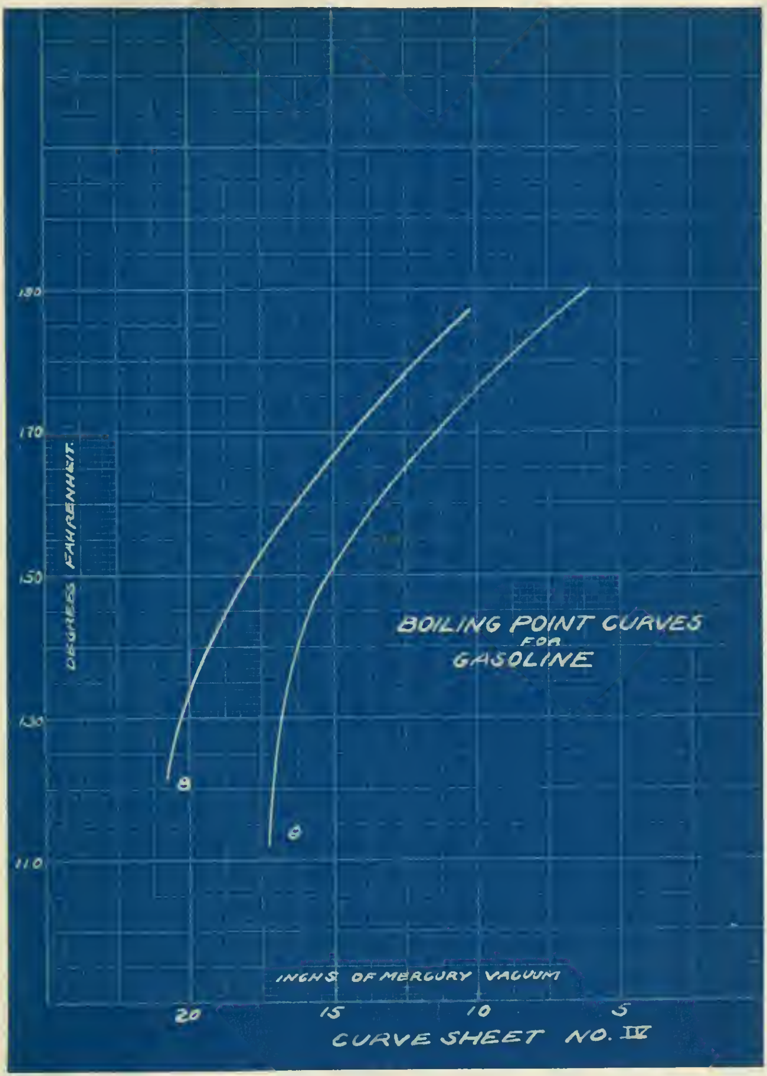
A change of pressure affects all the boiling points in a similar manner. Curves No.8 and 9 on Curve Sheet No.IV show the relation of boiling point to pressure of two samples of gasoline. No.8 is from the Consumers Mutual Company, and No.9 is Red Crown gasoline. The initial boiling point only was recorded. Curve No.9 shows that this sample was more volatile than No.8. There was a difference of about 0.5 inch barometer reading on the days which the data was taken, but this would make a very slight difference in the results.

The values of boiling points and pressure as observed in this work are sometimes reached in automobile



CONSUMERS MUTUAL CO.		RED CROWN		STANDARD OIL CO.	
GASOLINE		GASOLINE		KEROSENE	
BAROMETER 29.48		BAROMETER 28.95		BAROMETER 29.48	
VACUUM	BOILING TEMP.	VACUUM	BOILING TEMP.	VACUUM	BOILING TEMP.
IN. HG.	DEGREES F.	IN. HG.	DEGREES F	IN. HG	DEGREES F.
21	121	17	112	19.8	DID NOT BOIL 191
19	145	14	158		
17	156	12.5	165		
15.3	164	10	175		
13	174	8.5	183		
11.5	181	6	191		
10.3	191	4	DID NOT BOIL 191		
8.5	DID NOT BOIL 191				

TABLE NO. II



BOILING POINT CURVES FOR GASOLINE

CURVE SHEET NO. IV

practice. On a hot summer day the gasoline in a tank near the engine could easily reach a temperature of 112° F. and under conditions of vacuum likely to arise, might start to boil. This would be dangerous in an enclosed tank. This fact might be stated as an objection to a vacuum feed system.

PART III.

MEASUREMENTS OF FLOW -

TAPER PIN FLOW METER

INDICATING FLOW METER

PROPOSED INDICATING FLOW METER.

TAPER PIN FLOW METER.

The measurement of the instantaneous flow of gasoline is very desirable in the testing of engines. The present method of obtaining the economy of a gasoline engine is to measure the fuel consumption during a certain length of time. This method would be accurate if the conditions were exactly uniform during the run, but this is seldom the case. By means of an indicating device which reads the instantaneous flow, any slight variation could be noted. If the cause of this variation was found, the best running condition of the engine could be accurately determined. An instrument for obtaining this instantaneous reading would therefore be of value.

With this end in view, an attempt was made to construct a metering device which would indicate the required reading. A flow-meter, the design of which is shown in Figure 3, was constructed. Patterns were made according to the dimensions of Figure 2 and the castings poured in the foundry. The material used was brass. The castings were then turned and finished and a cover plate made for the chamber (B). The pet-cock (D) was tapped into the bottom

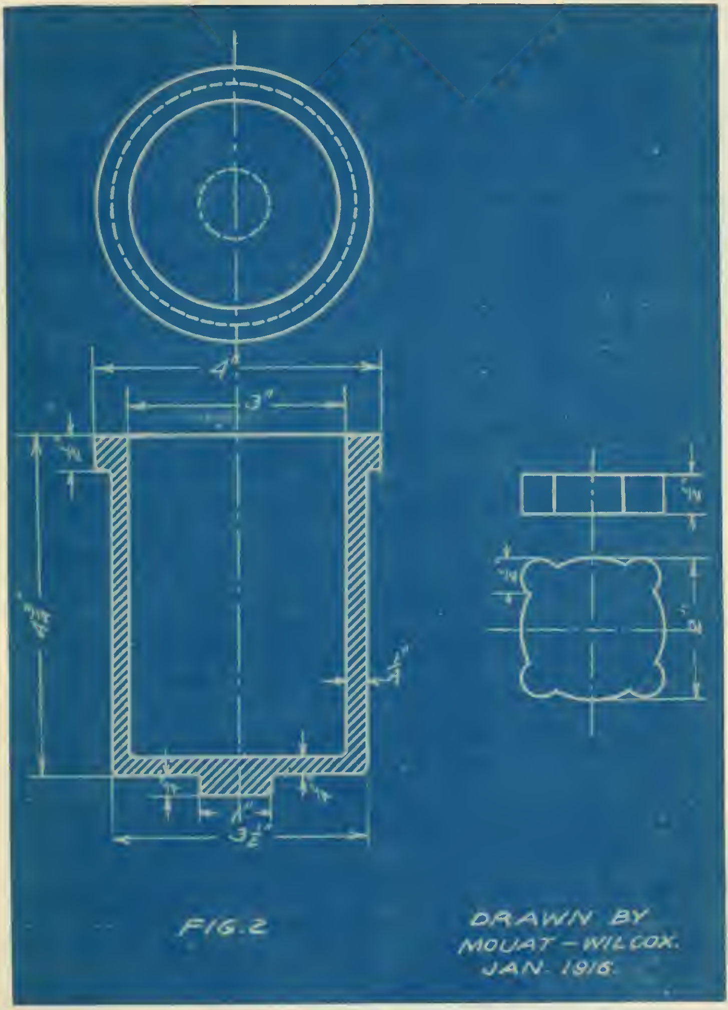
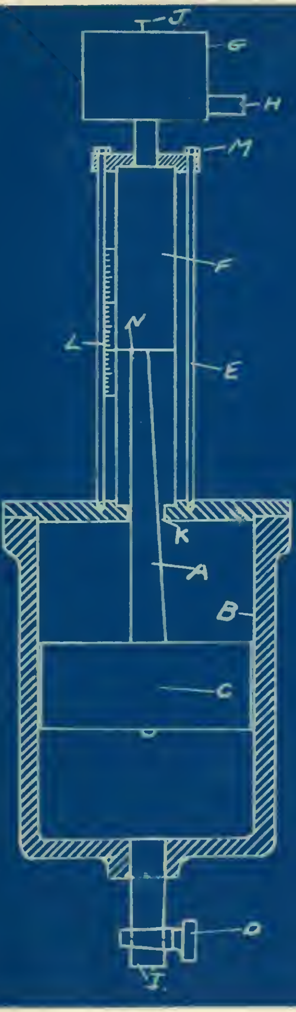


FIG. 2

DRAWN BY
MOUAT – WILCOX.
JAN. 1916.

of the chamber, the rods (E) and nuts(M) adjusted to hold the glass tube (F) in place, and a pipe connection from the constant level float (G) was tapped so as to discharge into the tube. The float (C) was made of cork and such a size as to allow a slight clearance. The tapered pin (A) was made of aluminum and of rectangular cross-section with a slight taper on one edge. Several pins were milled down before a perfect one could be obtained - flaws in the aluminum caused most of the trouble. An arbitrary taper was cut on one edge. This taper was to be more accurately determined after trials had been made of the operation of the pin. The pin was attached to the float by means of a small screw extending through the cork. Small wire guides were placed around the circumference of the cork to make it travel straight up and down, and to keep it from adhering to the sides of the chamber.

In the center of the cover plate was cut a rectangular orifice (K) of the same cross-section as the larger end of the pin. This orifice was carefully filed until the pin fitted it accurately and could be made to slide up and down freely.



M'K.	NAME.
A.	PIN
B.	CHAMBER
C.	FLOAT
D.	PET-COCK
E.	SUPPORTS
F.	TUBE
G.	C. L. FLOAT.
H.	INLET
I.	OUTLET
J.	FLOODER
K.	ORIFICE
L.	SCALE
M.	NUTS
N.	POINTER

TAPER PIN

FLOW METE

FIG. 3

Leather washers were placed at each end of the glass tube, a paper gasket made for the joint between chamber and cover, and all joints shellacked until they were gasoline-tight. The instrument was then ready for operation.

The manner in which the device was supposed to work is as follows: Gasoline would be permitted to flow into the chamber with the pet-cock closed. In a short time this chamber would fill up and then the pet-cock could be opened and gasoline drawn off at variable rates of flow. The gasoline in the float chamber would raise the cork float, to which is attached the metering pin, and partially shut off the supply from above. As the gasoline was being removed from the chamber through the pet-cock, the float would drop and make a larger opening above. When the size of the opening was such that it allowed enough gasoline to flow in to compensate for that which was removed, the position of the top of the tapered pin could be read on a calibrated scale, and thus the gasoline consumption would be indicated. To obtain a constant head of gasoline at the inlet of the instrument, the constant level float was inserted in the line.

In theory, this seemed to be an ideal meter but practically, many difficulties were encountered. The main one was in the operation of the pin: a slight change of temperature had a very noticeable effect upon the fit of the pin in the orifice. Due to expansion and contraction the pin was either jammed in the hole or too loose to indicate properly. Another difficulty noticed was the collection of an oxide upon the pin and cover plate after the device had stood for a few hours with gasoline in it. Still another obstacle was the tendency of the instrument to become air bound. No doubt some provision was necessary for allowing the air to escape before the gasoline would flow steadily.

The change of the viscosity of gasoline, due to the change of temperature, as pointed out in Part I, would undoubtedly have had some effect upon the indications of the above meter. The intentions were to calibrate it for the range of temperature likely to occur, but owing to the difficulties encountered, it was decided to give up this type of meter.

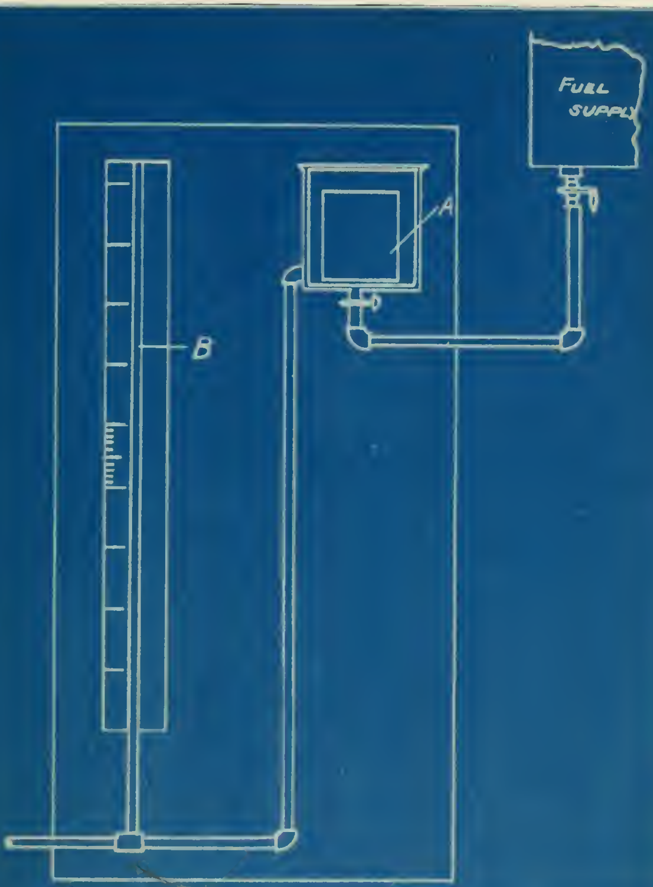
INDICATING FLOW METER.

The apparatus used in making the consumption tests of Dorman engines, while not entirely new, is of sufficient interest to merit a description.

The apparatus, Figure 4, consists of a float (A) arranged so that at rest there is a constant level of gasoline in an open air tube (B). When gasoline is drawn away to the carburetor, the velocity of flow past the lower end of pipe B causes the level in the pipe to fall. This fall is constant for any given velocity in the horizontal pipe, but varies with this velocity. Consequently, on a suitably calibrated scale, it is possible to read the flow of gasoline in any units. The scale is graduated to show pints per hour, so that the consumption can be obtained instantly.

The advantage of thus being able to ascertain the effect of even the most minute alteration to the carburetor setting will be readily understood.

An apparatus similar to that used in testing Dorman engines was constructed. A run was attempted, but owing to the fact that the total drop of the surface of the gasoline in the tube was only about two inches, slight variations were hardly noticeable.

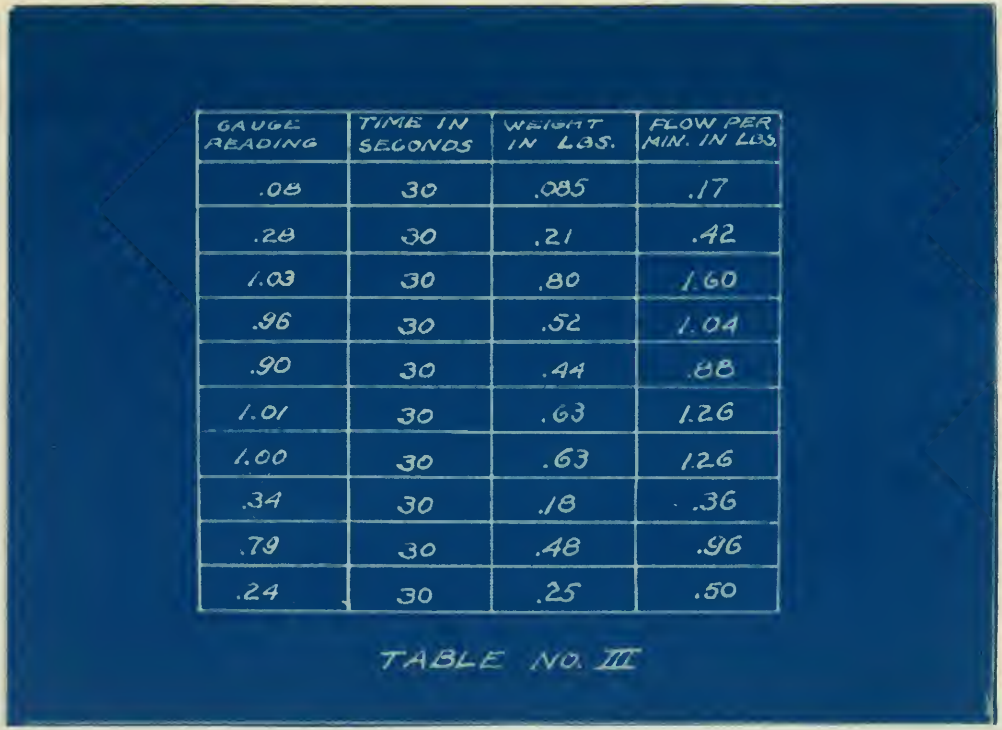


DORMAN'S FUEL CONSUMPTION GAUGE

FIG. 4

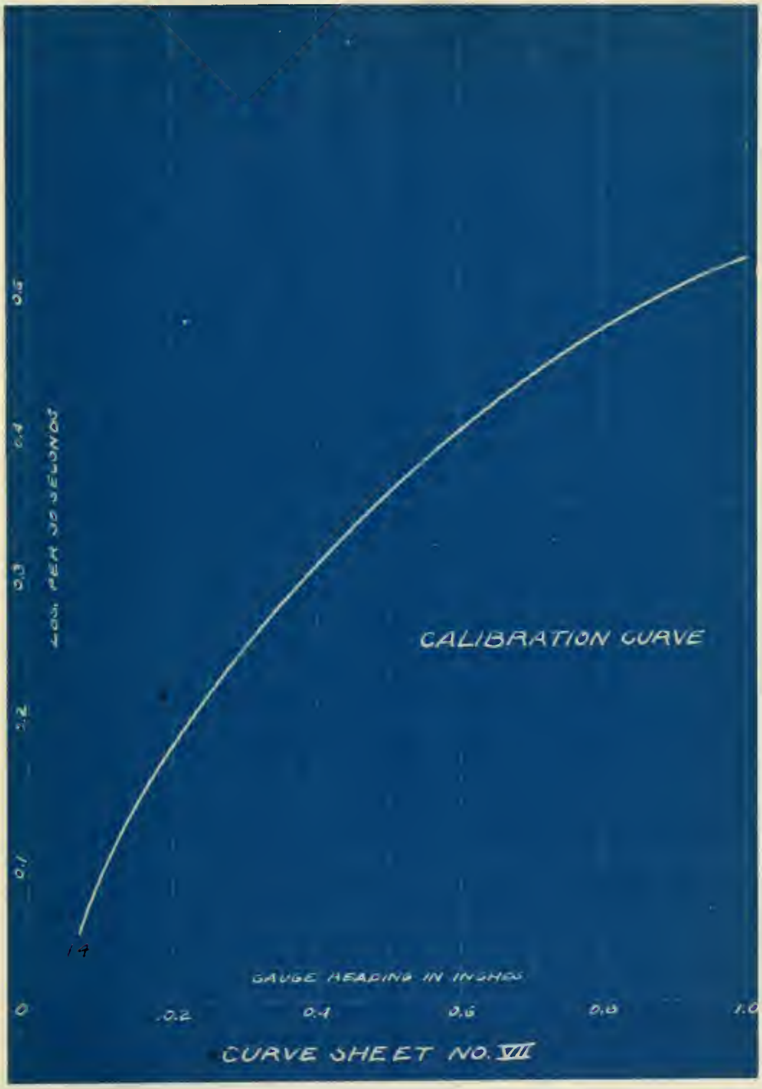
To exaggerate these variations, a differential gauge was connected to the vertical riser. The gauge was set for a one to five slope so that the slightest variation in flow could readily be detected on the scale of the gauge.

Owing to the construction of the gauge, the gasoline had to be siphoned into the tube along which the scale was placed. The only possible arrangement of piping allowed a place for an air pocket and this had a bad effect on the readings. The column of air would contract or expand and cause erroneous readings. A calibration run was made and fairly good results obtained in spite of the chance for error. The data is given in Table No.III and is shown plotted in curve No.14 on Curve Sheet No.VII. The gauge readings are in inches of gasoline and as the gauge is at a one to five slope, and its scale magnified five times, one tenth of an inch vertical rise is equal to one tenth of an inch on the scale. The gasoline flowing for a period of thirty seconds was run into a flask, weighed on a sensitive scale, and recorded for several rates of flow. The flow was regulated by means of a pinch-cock on the end of a rubber tube.



GAUGE READING	TIME IN SECONDS	WEIGHT IN LBS.	FLOW PER MIN. IN LBS.
.08	30	.085	.17
.28	30	.21	.42
1.03	30	.80	1.60
.96	30	.52	1.04
.90	30	.44	.88
1.01	30	.63	1.26
1.00	30	.63	1.26
.34	30	.18	.36
.79	30	.48	.96
.24	30	.25	.50

TABLE NO. III



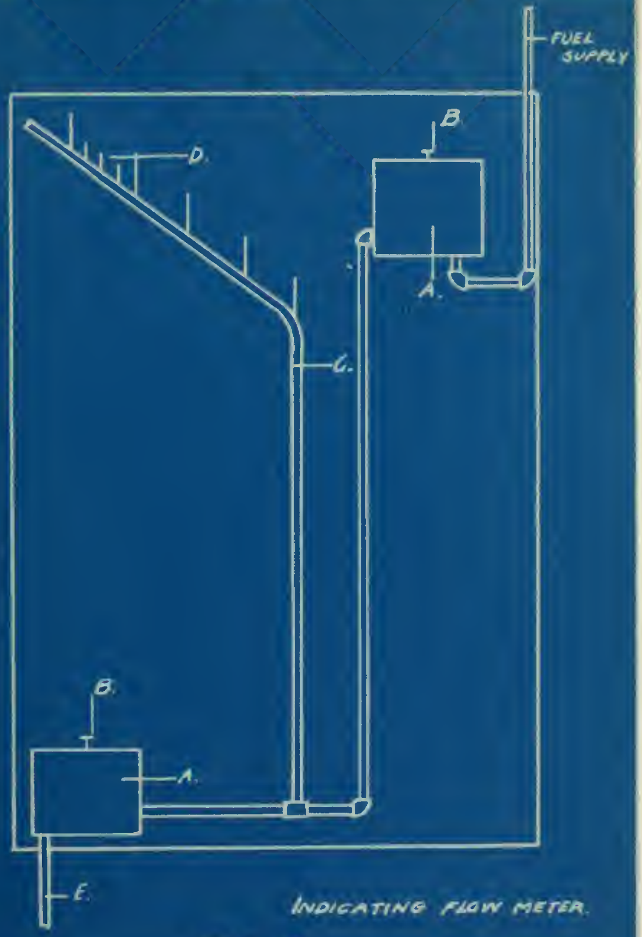
CURVE SHEET NO. VII

As the results did not check very closely, it was decided to experiment further until a better scheme was devised.

A sloping tube was used in place of the vertical riser and another constant level float was connected in, as shown by Figure 5. The slope of the tube was made such that a vertical rise of one-tenth of an inch was represented by four tenths of an inch along the tube. As the surface of the liquid in the tube was not horizontal, due to capillary action, the position of one end of the curve was read each time.

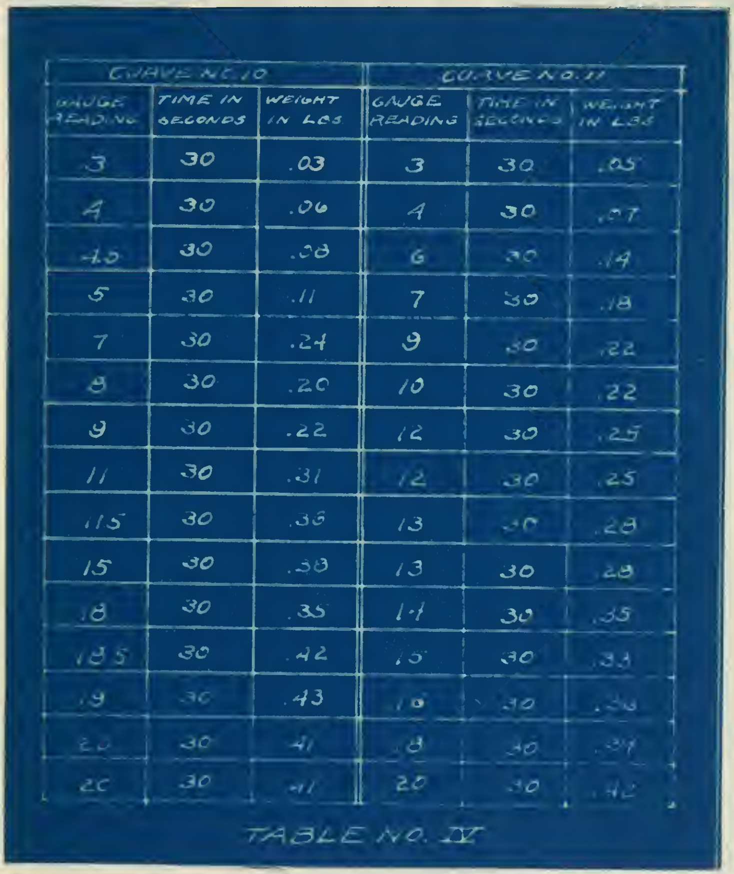
The theory of this instrument is as follows: The level of the gasoline in the float chambers (A) remains constant at all times and therefore the head is constant. The flow is therefore proportional to the velocity. The height of the liquid in the tube (C) is also proportional to the velocity past its mouth, and a reading on the scale (D) is therefore an indication of the flow through the outlet (E).

Two calibration runs were made, the results of which are given in Table No.IV, and are shown plotted as curves No. 10 and 11 on Curve Sheet No.V. The curves were not drawn through each point but along the general line of points.



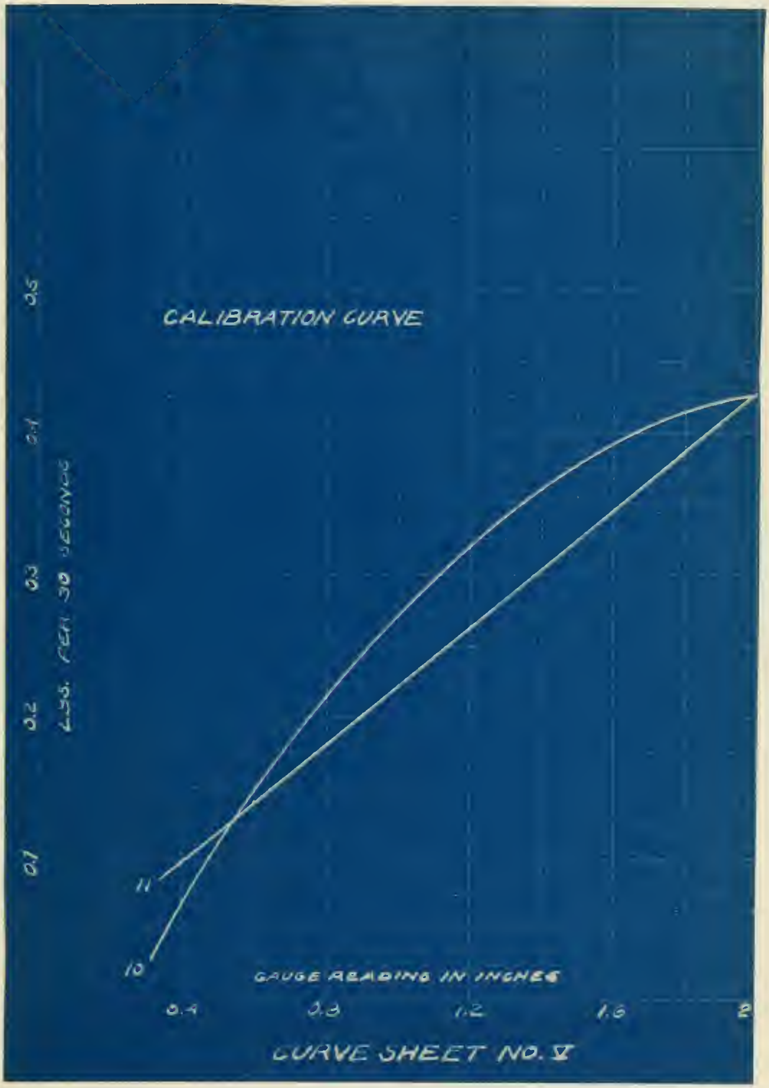
INDICATING FLOW METER.

FIG. 5



CURVE NO. 10			CURVE NO. 11		
GAUGE READING	TIME IN SECONDS	WEIGHT IN LBS.	GAUGE READING	TIME IN SECONDS	WEIGHT IN LBS.
3	30	.03	3	30	.05
4	30	.06	4	30	.07
4.5	30	.08	6	30	.14
5	30	.11	7	30	.18
7	30	.24	9	30	.22
8	30	.20	10	30	.22
9	30	.22	12	30	.25
11	30	.31	12	30	.25
11.5	30	.36	13	30	.28
15	30	.38	13	30	.28
18	30	.35	14	30	.35
18.5	30	.42	15	30	.33
19	30	.43	16	30	.36
20	30	.41	18	30	.37
20	30	.41	20	30	.42

TABLE NO. IV



CALIBRATION CURVE

CURVE SHEET NO. V

This method was warranted by the fact that many small errors creep in which would throw the curve off more than the distance which some of the points are from the general line. Some of the points were checked several times and these were given more weight in plotting the curve than other more questionable points.

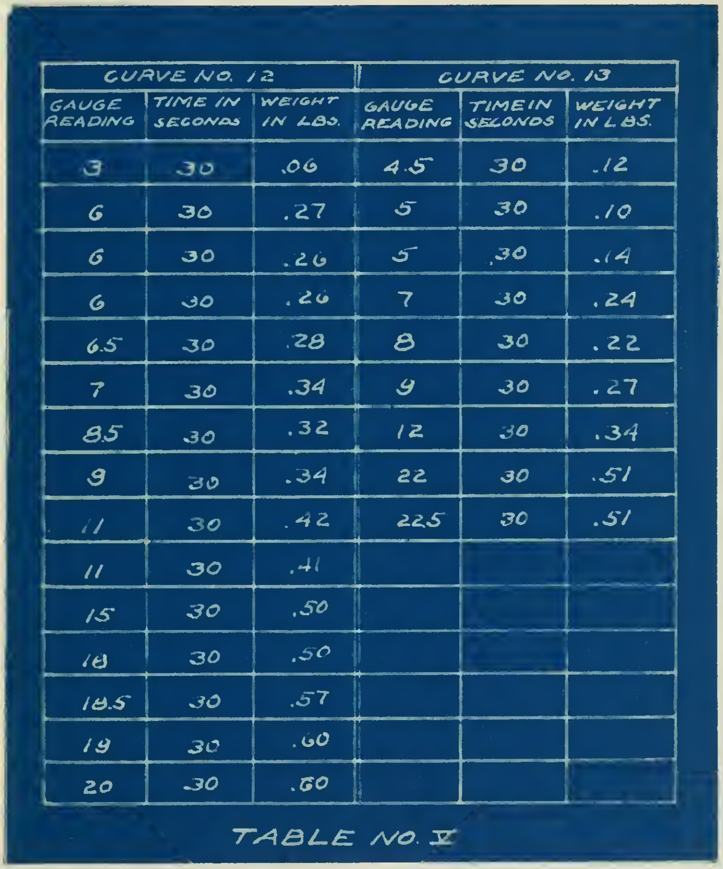
After the light runs it was noticed that the liquid did not always return to the zero mark. The cause of this was the lack of sensitiveness of the upper float. This was remedied somewhat by carefully leveling the float and adjusting all the moving parts so that they worked freely. If the pin of the needle valve had been of a smaller taper, the instrument would probably have been more sensitive. By means of the flooder (B), the float could be lifted and enough gasoline allowed to run in to bring the level back to the zero mark.

Another probable cause of error was the sucking effect due to the level of the end of the outlet tube (E). A change of this level would cause a change of suction pressure and cause erroneous readings. If the device were actually attached to an engine; this trouble would not be encountered.

The curves No.10 and 11 seem to show entirely different calibrations. This is probably accounted for by the fact that a few bad points may change the shape of the curve. Due to these inconsistencies a still better method was looked for and found in the substitution of an inverted draft gauge for the sloping tube.

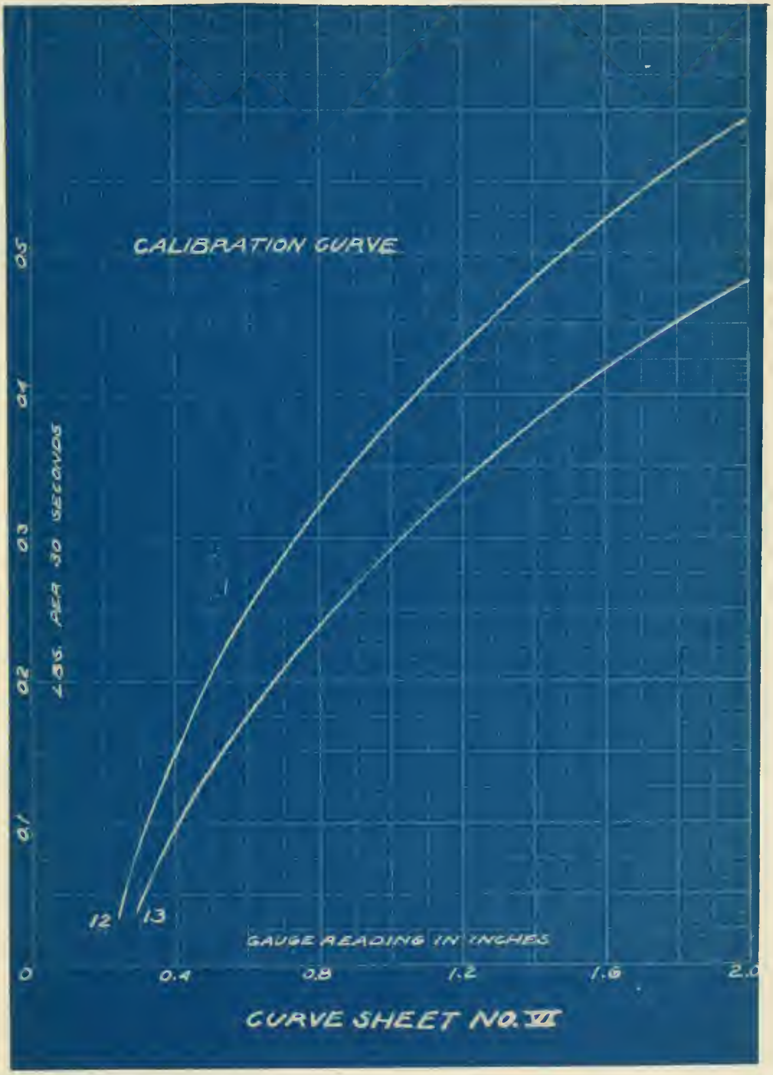
By the inversion of the draft gauge, the piping which allowed the air pocket was cut out and an accurate and easy method of reading the scale provided. The gauge was connected at the point (C) in Figure 5, and set so as to give a one to five slope. This arrangement worked very satisfactorily. The mechanical construction was nearly perfect and the only possible errors were those which arose from the personal element, such as errors in the timing and reading the scale.

A run was made, the results of which are given in Table No.V, and are shown plotted in curve No.12 on Curve Sheet No.VI. The points on this run are not any of them far off the curve and it is taken as the correct calibration. The gauge reading is in inches of gasoline vertical rise and the flow is in lbs. of gasoline per thirty seconds. These readings could easily be reduced to



CURVE NO. 12			CURVE NO. 13		
GAUGE READING	TIME IN SECONDS	WEIGHT IN LBS.	GAUGE READING	TIME IN SECONDS	WEIGHT IN LBS.
3	30	.06	4.5	30	.12
6	30	.27	5	30	.10
6	30	.26	5	30	.14
6	30	.26	7	30	.24
6.5	30	.28	8	30	.22
7	30	.34	9	30	.27
8.5	30	.32	12	30	.34
9	30	.34	22	30	.51
11	30	.42	22.5	30	.51
11	30	.41			
15	30	.50			
18	30	.50			
18.5	30	.57			
19	30	.60			
20	30	.60			

TABLE NO. V

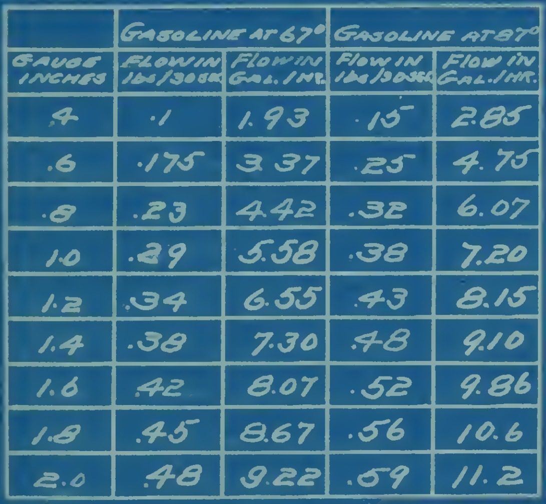


CURVE SHEET NO. VI

any units desirable.

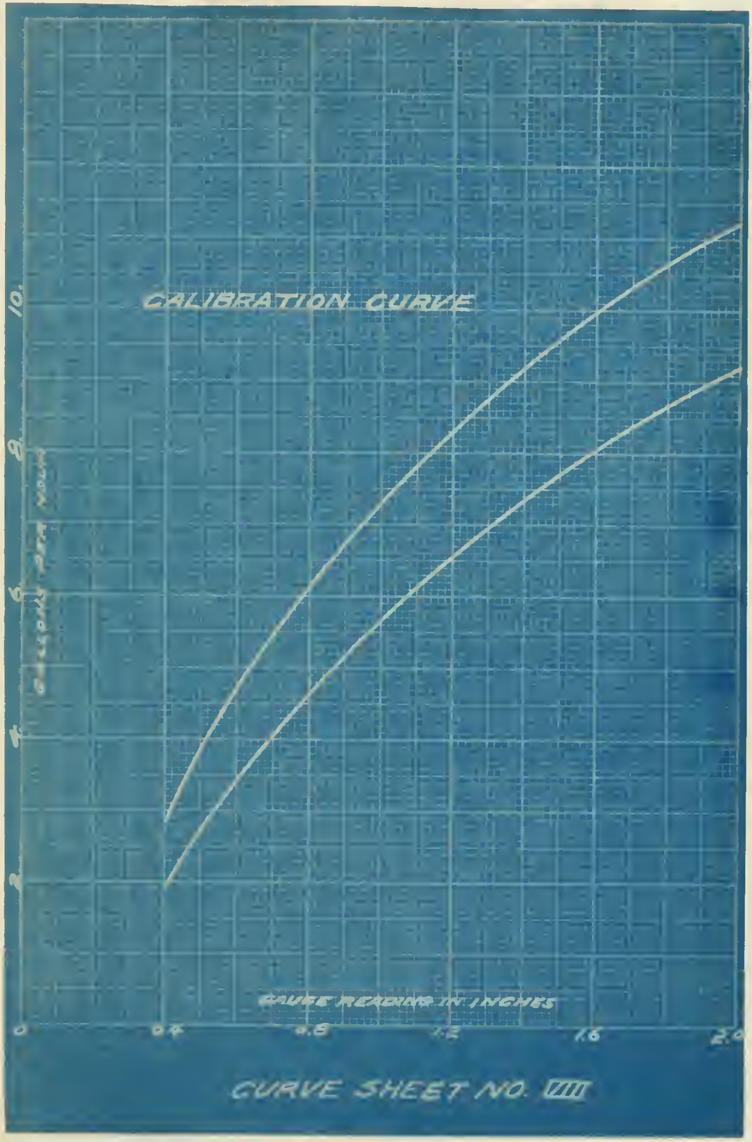
In accordance with Part I of this thesis, it was desirable to determine the effect of heat on the readings of this meter. A considerable quantity of gasoline was heated to about 90° F., a temperature about 20 higher than that of the other samples. As the gasoline cooled somewhat during the testing, the temperature was taken before and after and the average used. The results of a run made with this heated gasoline are given in Table No.V and are shown plotted in Curve No.13 on Curve Sheet No.VI. It may be seen that this change of temperature causes quite an appreciable difference. There are so many variables that might cause this difference that an explanation is not attempted - it is merely left as an experimental fact.

The curves on Curve Sheet No.VI were replotted, using gallons per hour as abscissas. It was thought that the change of density due to change of temperature as shown by the volume measurements, might influence the shape of the curves or their relation. Curve Sheet No.VIII shows that there is no material difference.



	Gasoline at 67°		Gasoline at 87°	
Gauge Inches	Flow in lbs/30 sec	Flow in Gal./Hr.	Flow in lbs/30 sec	Flow in Gal./Hr.
.4	.1	1.93	.15	2.85
.6	.175	3.37	.25	4.75
.8	.23	4.42	.32	6.07
1.0	.29	5.58	.38	7.20
1.2	.34	6.55	.43	8.15
1.4	.38	7.30	.48	9.10
1.6	.42	8.07	.52	9.86
1.8	.45	8.67	.56	10.6
2.0	.48	9.22	.59	11.2

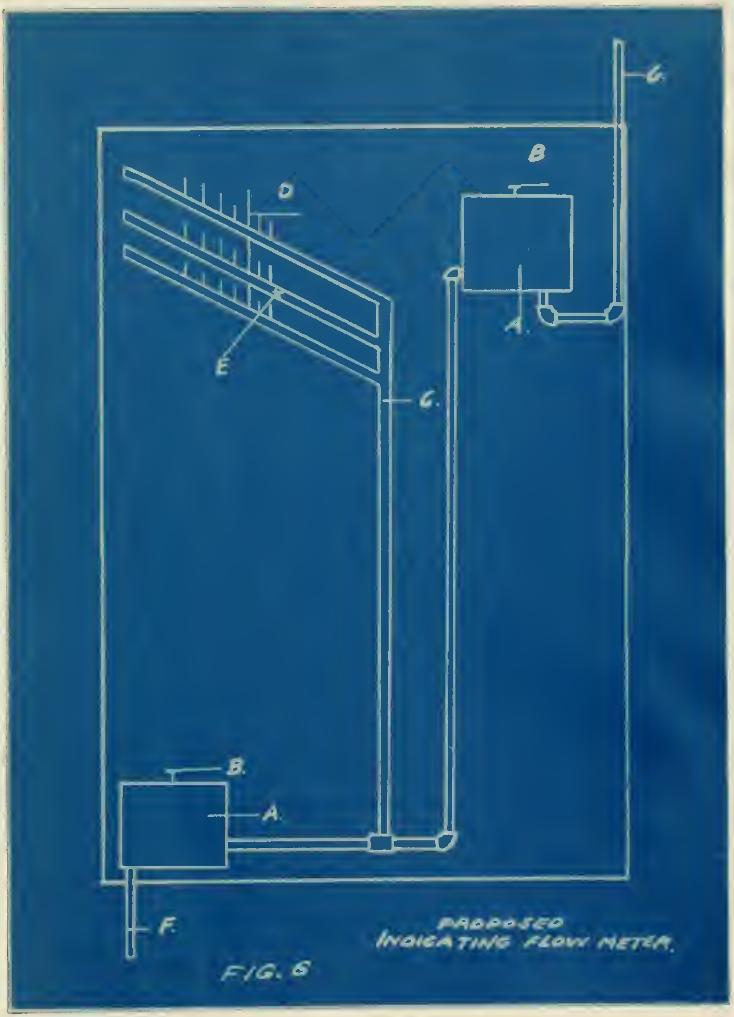
TABLE No VI



CURVE SHEET NO. VIII

PROPOSED INDICATING FLOW METER

A still greater refinement which might be suggested is the dividing up of the scale. A sketch of this arrangement is shown in Fig. 6. The sloping tube is divided into three parts by means of a sort of a ladder arrangement, so that the first inch of rise is indicated on the lower scale, the second on the center scale, and the third on the upper scale. The secondary riser at the left of the ladder is open to the atmosphere so that the tubes will not become air bound. The advantage of this arrangement over a single tube such as a draft gauge is that for a given slope the space requirements are much less. This instrument would no doubt give accurate results of even the slightest flow.



PROPOSED
INDICATING FLOW METER.

FIG. 6

Appendix.

BIBLIOGRAPHY

Automobile, March 23, 1916.

Motor Age, April, 1912.

Smithsonian Tables.

We are also indebted to Mr. F. Purdy and Mr. E. Morris of the Rayfield Carburetor Company, for suggestions and apparatus, and to Mr. R. H. Lindsay of the Vacuum Oil Company for data.